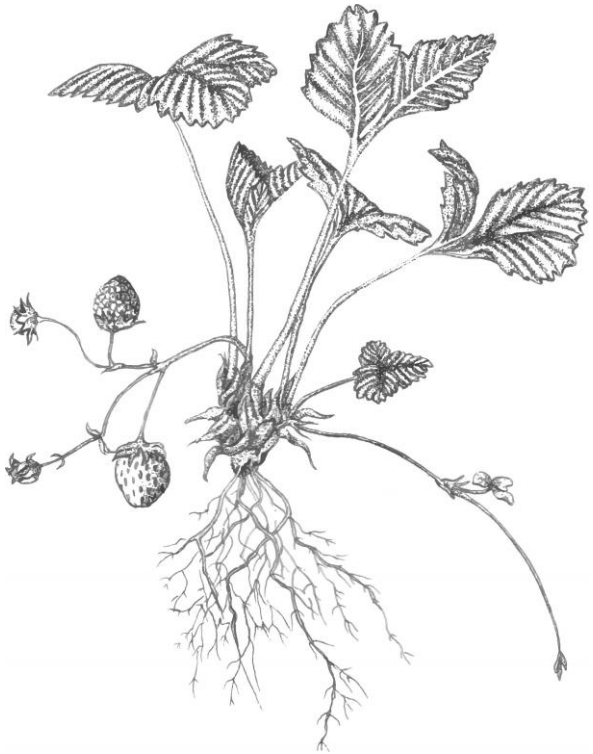
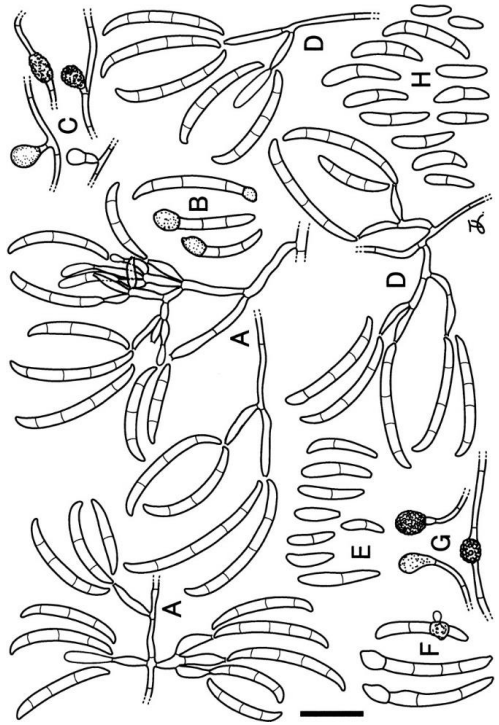
Updates on Fusarium wilt research: Aerial dispersal and resistance-breaking strains



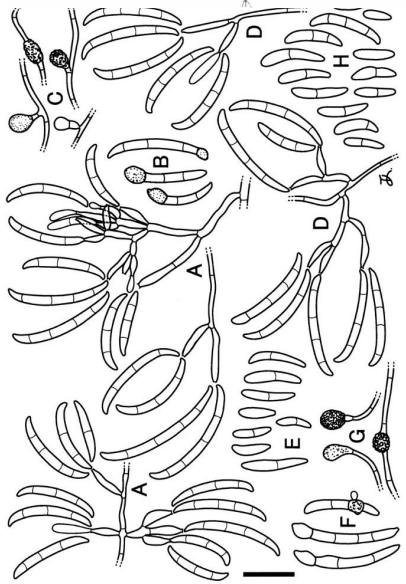
Peter Montgomery Henry, PhD
Research Plant Pathologist

Annual Strawberry Production
Research Meeting
UCCE – Santa Cruz / Monterey
Feb 7, 2023

USDA ARS Agricultural Research Service



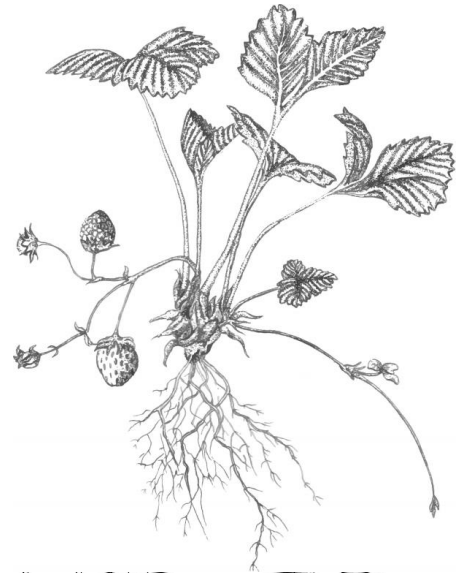
Overview

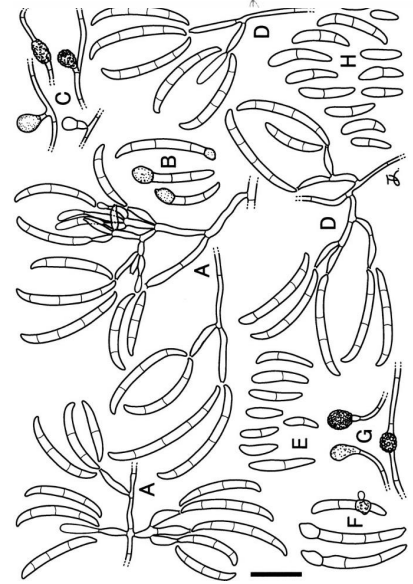


Fof has the potential for aerial dispersal

Resistance-breaking *Fusarium oxysporum f. sp. fragariae (Fof)* race 2 in CA

- Background on Fof races
- Discovery
- Response
- What we know





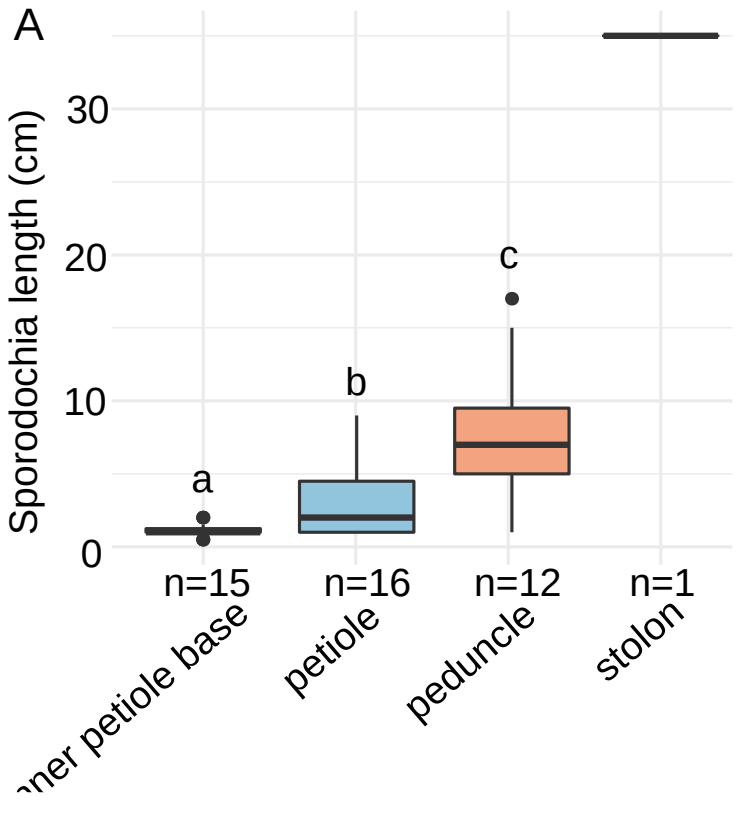
Fusarium wilt

Signs: None

Symptoms: Stunting, chlorosis and deformation of new leaves are early symptoms. Wilting first of outer leaves or sudden collapse of entire plant can also occur.

Sporodochia formed by *F.o. fragariae*

- Discovered at 87% of Fusarium wilt-afflicted fields (*n*=24)
- Found on most plants



Henry et al. *in review*

Sporodochia formed by *F.o. fragariae*

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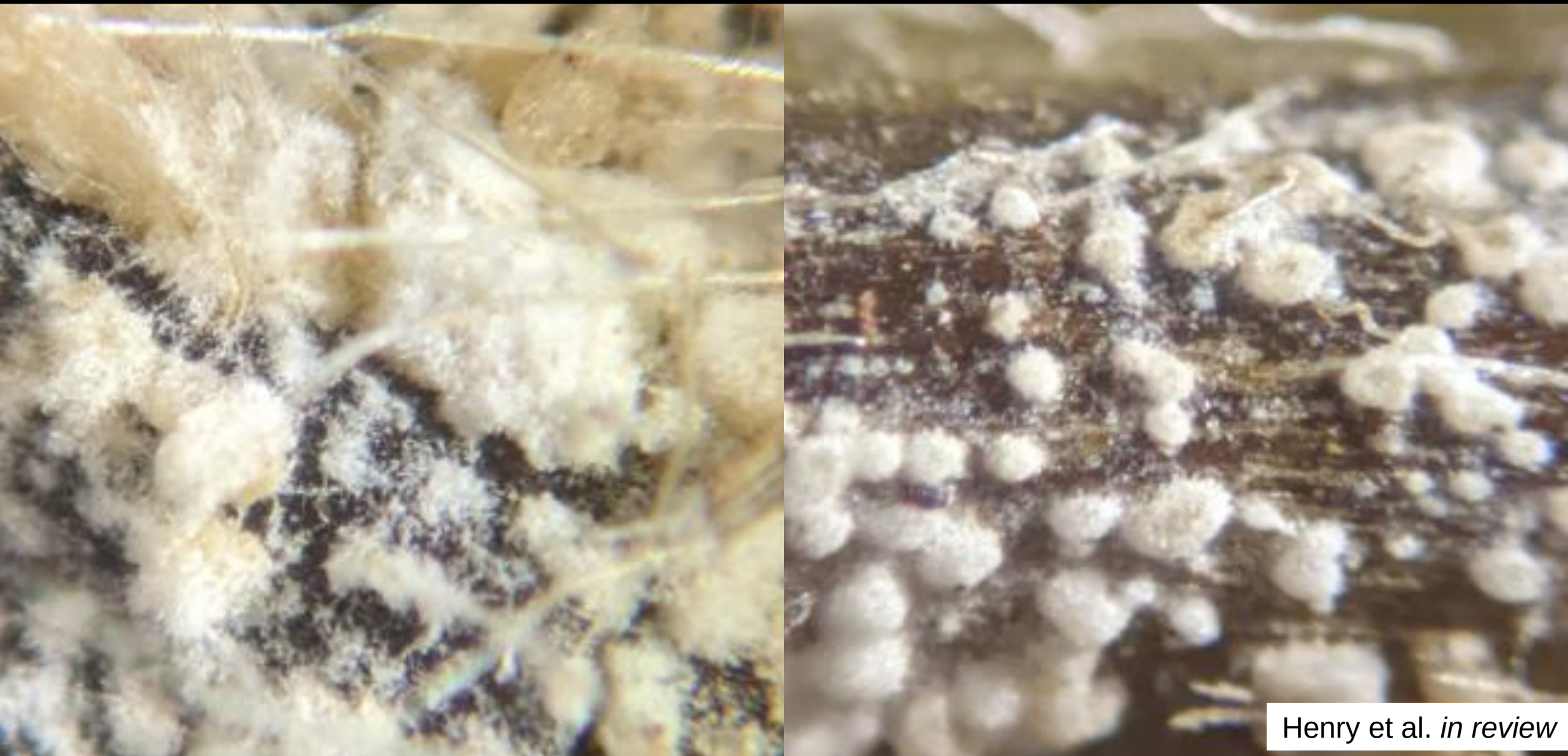
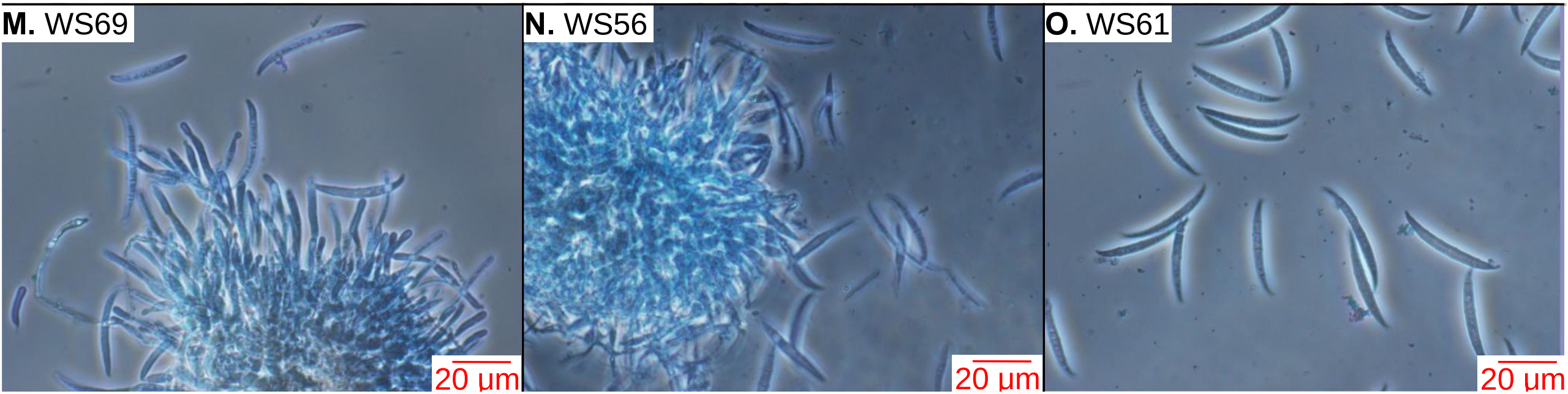


Henry et al. *in review*

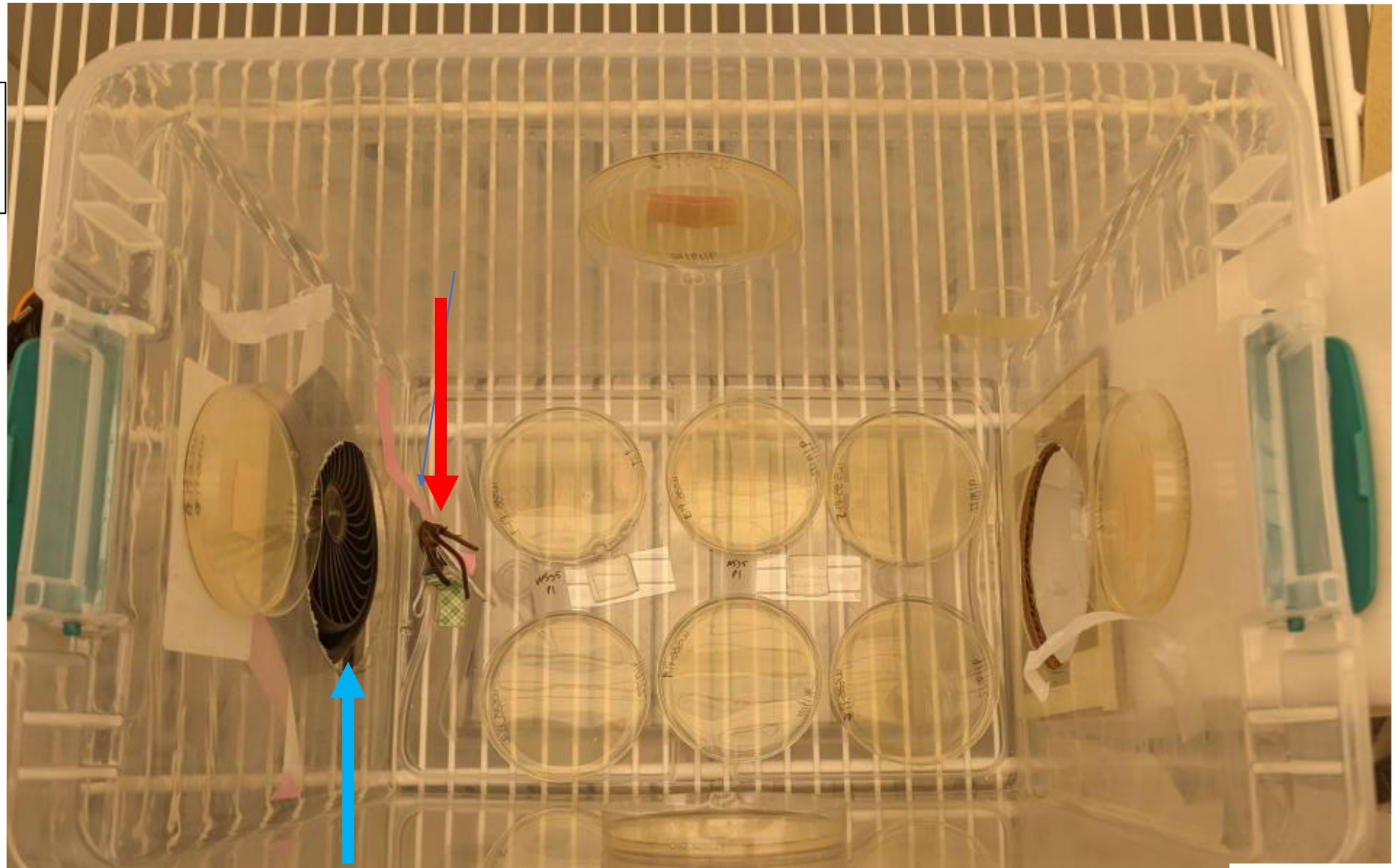
Only macroconidia observed



Henry et al. *in review*

Short-distance aerial dispersal

Windspeed
= 8.85 km/hr



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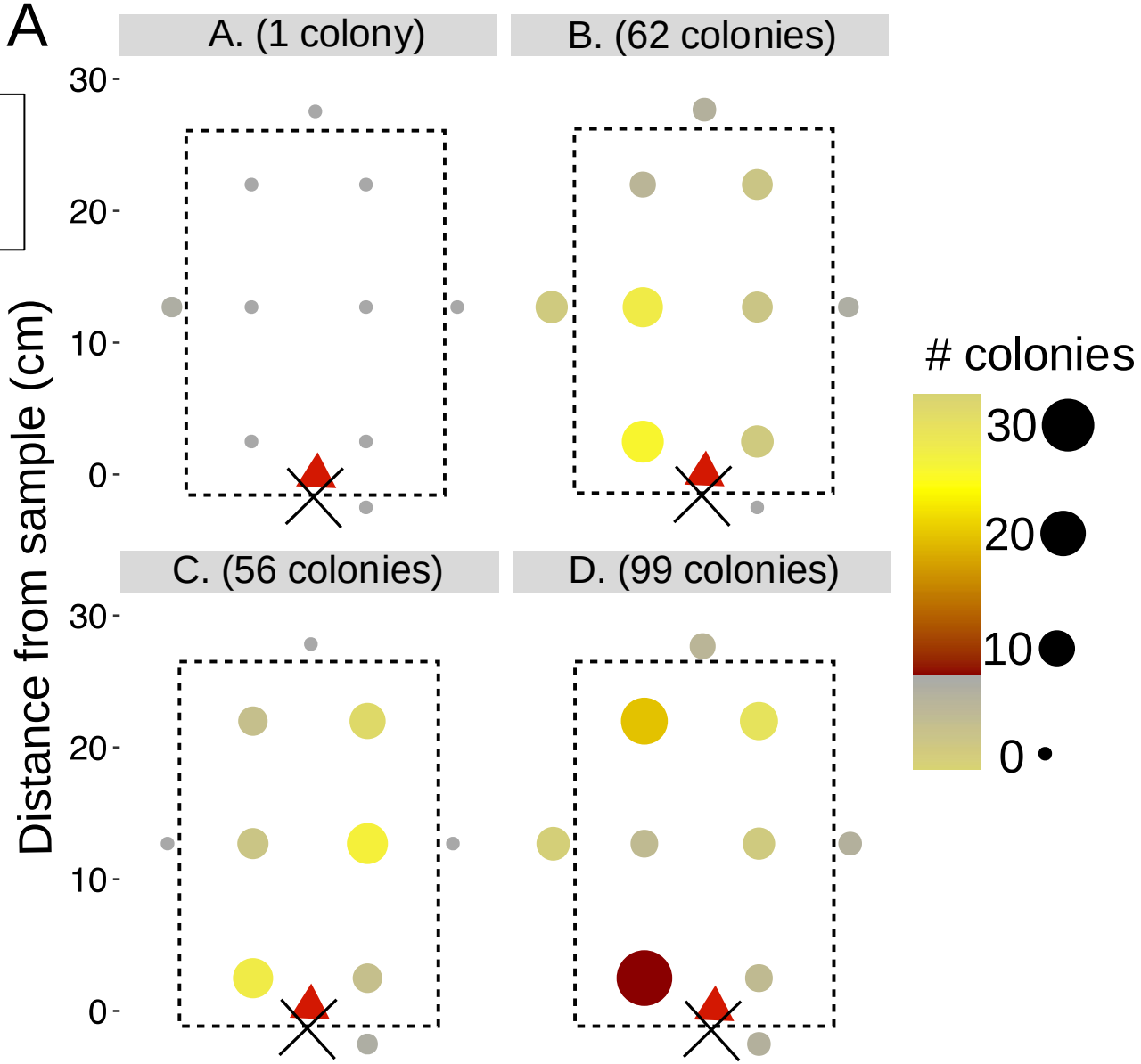
A



B

Henry et al. *in review*

Much higher windspeeds are common

- Bug vacuums are used 1x or 2x per week
- Vacuums generate windspeeds of 7-54 km/hr
- Afternoon windspeeds typically >14 km/hr

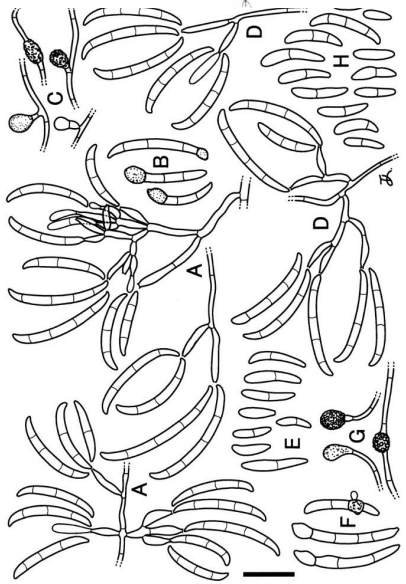
Takeaways

- Sporodochia are common in Watsonville/Salinas and have been observed near Oxnard

- Aerial dispersal is likely to contribute to field-to-field movement of this pathogen

- Future work:
  - Can aerially dispersed spores cause disease?
  - What is the long-distance range of airborne Fusarium conidia?
  - Can airborne spores account for some cases of ineffective flat fumigation?

Overview



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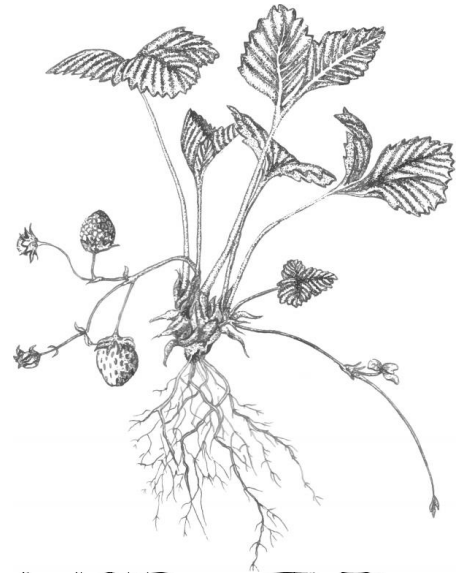
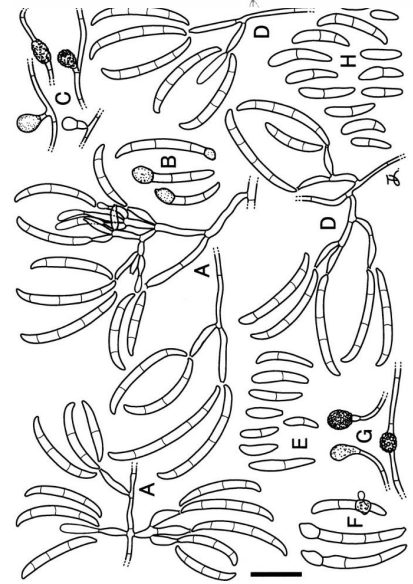
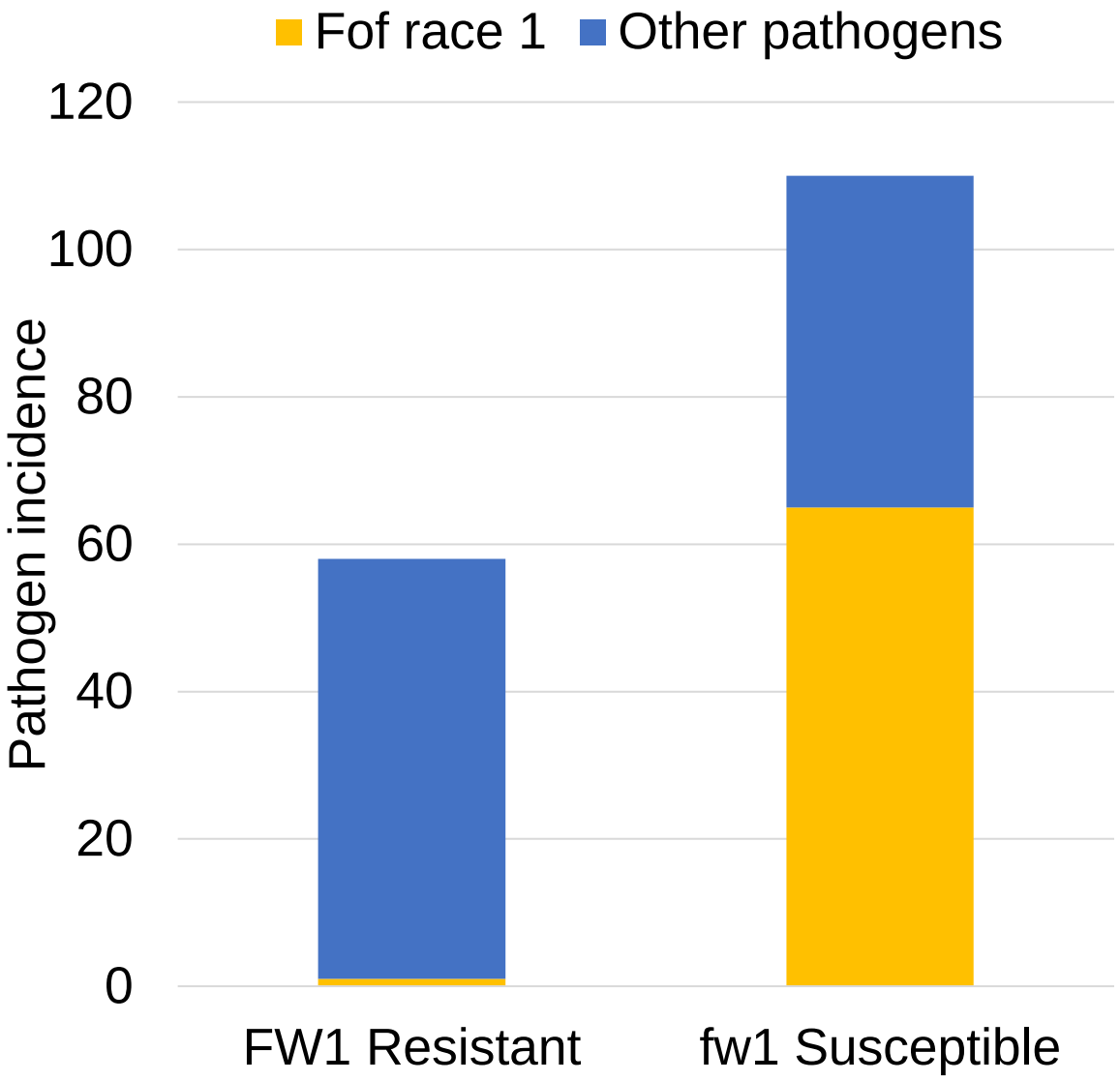


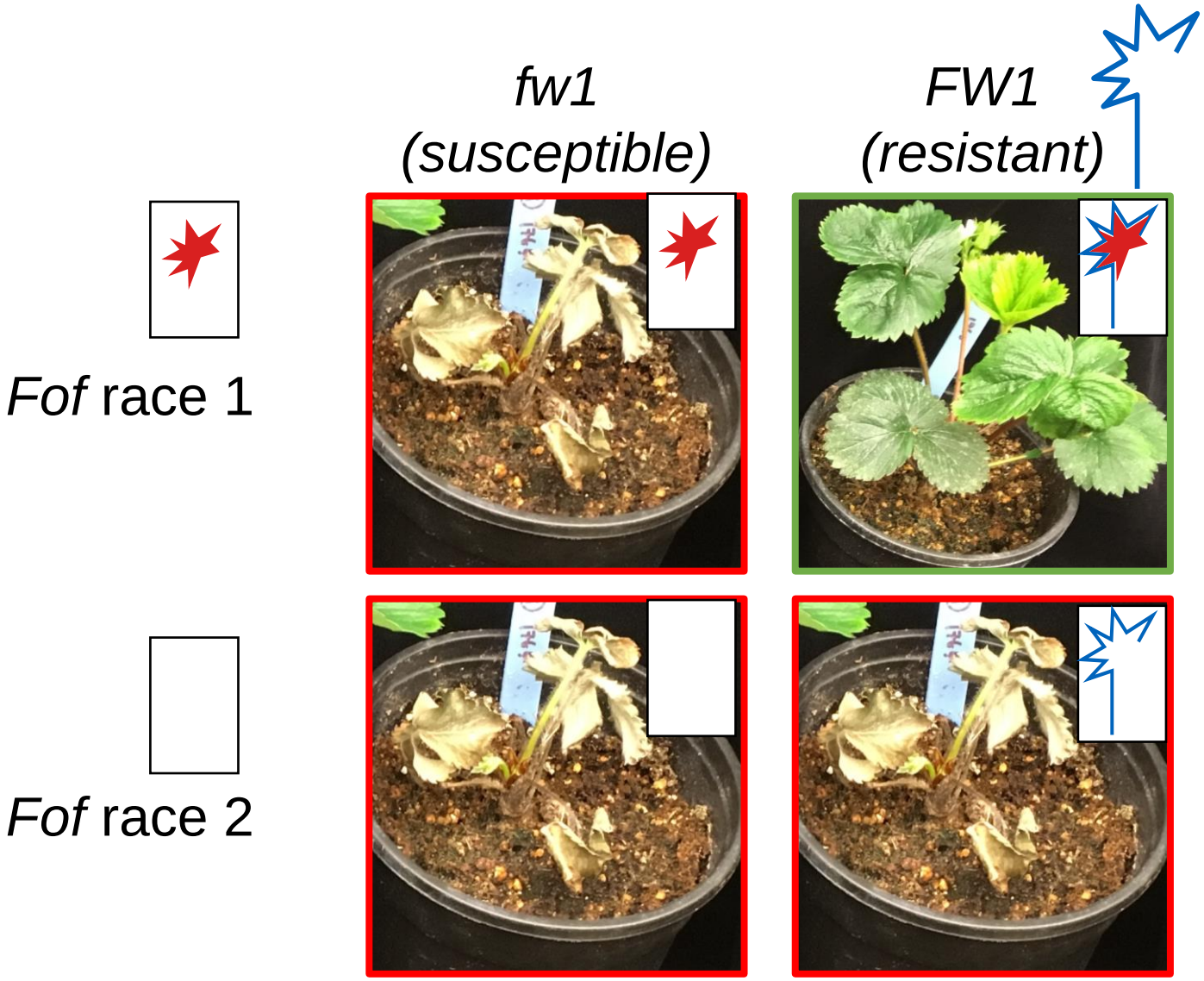


Genetic resistance is key to managing Fusarium wilt



- In Watsonville/Salinas, Fusarium wilt is the most common disease on susceptible varieties.
- Resistant varieties include:
  - Portola
  - Fronteras
  - San Andreas
  - Victor
  - Moxie

Gene-for-gene interactions in strawberry

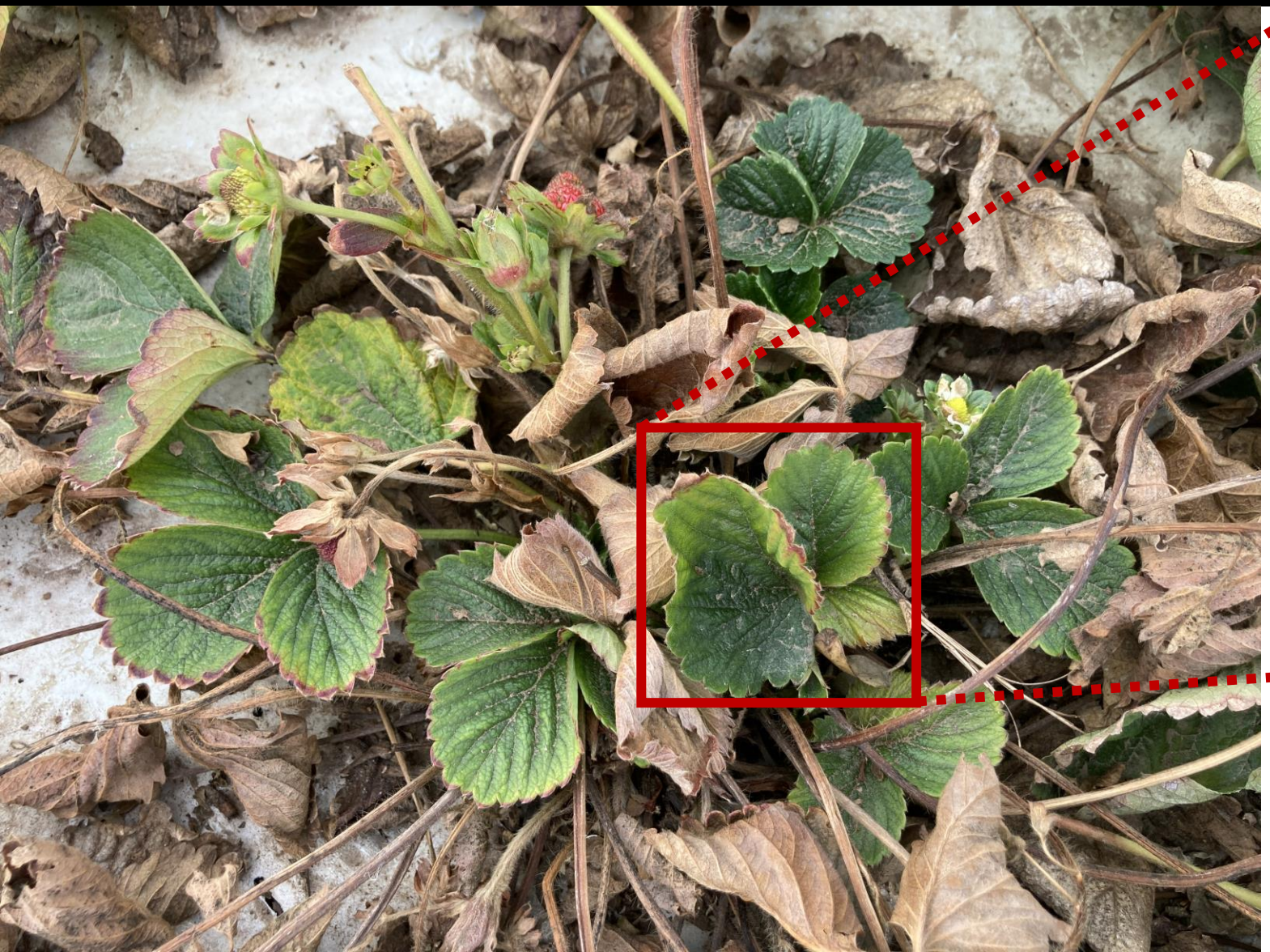


- *FW1* Resistant varieties:
  - Portola
  - Fronteras
  - San Andreas
  - Victor
  - Moxie

Ranch X on Sept 22, 2022:

- Summer-planted
- Organic
- Portola (*FW1*-resistant)
- High wilt disease severity
- Suspected *Macrophomina*

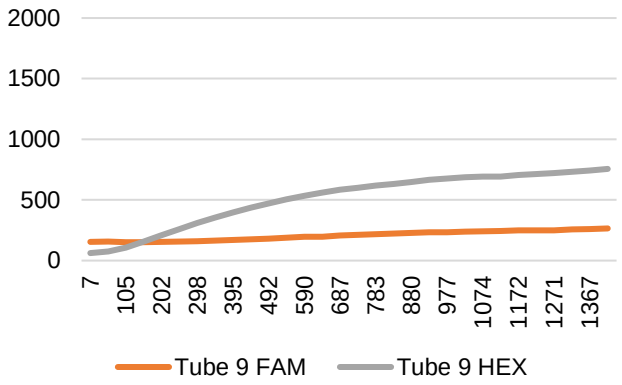
Fusarium-associated chlorosis



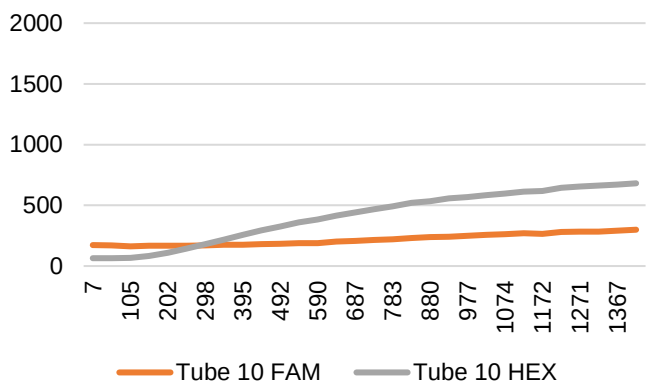
Inconclusive diagnostics

Molecular assays detected no pathogens

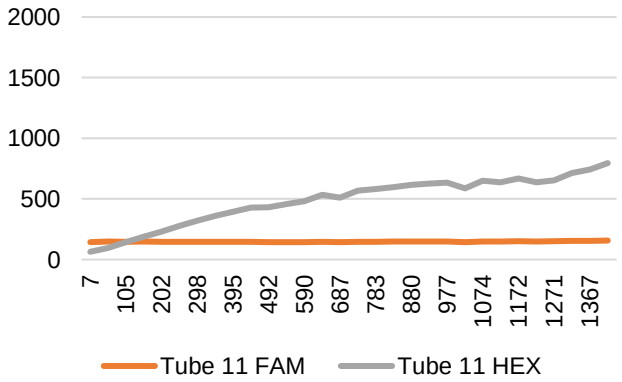
F.o. fragariae = Negative



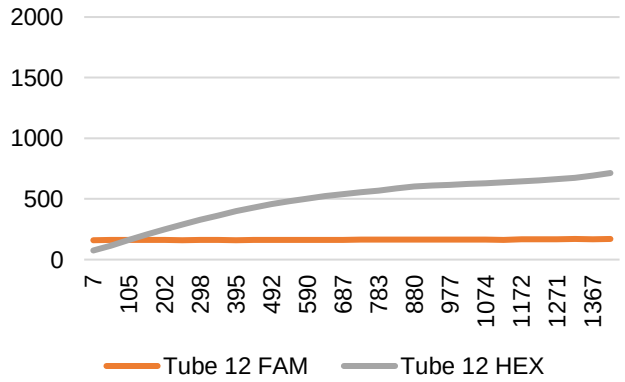
Macrophomina = Negative



Verticillium = Negative



Phytophthora = Negative



Petioles yielded abundant *Fusarium oxysporum*

Pathogenicity test confirms *Fof* race 2

Plants inoculated with pure *F. oxysporum* cultures from Ranch X

susceptible

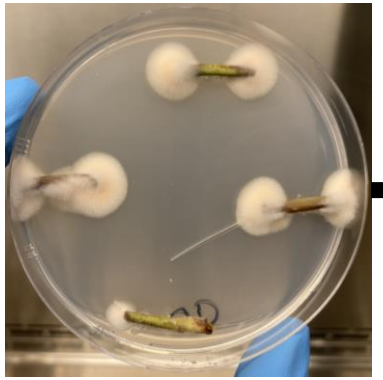
FW1 resistant

Early action plan

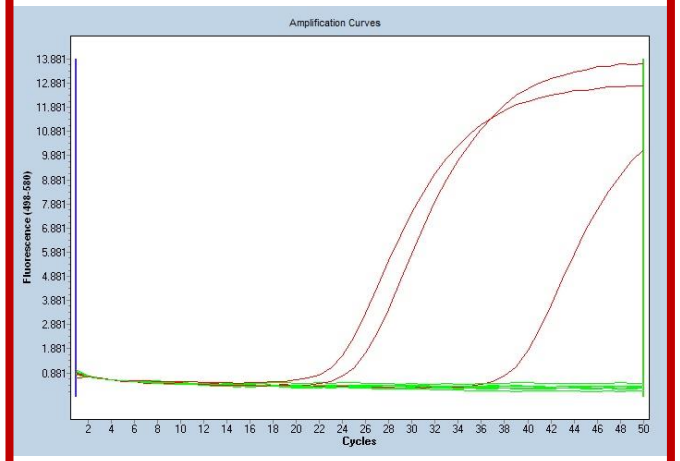
1. Survey incidence of *Fof* race 2 at Ranch X
2. Survey for *Fof* race 2 at other ranches
   - Ventura
   - Santa Maria
   - Watsonville/Salinas
3. Discuss best management practices with any affected grower
4. Develop preliminary detection methods

Current identification methods

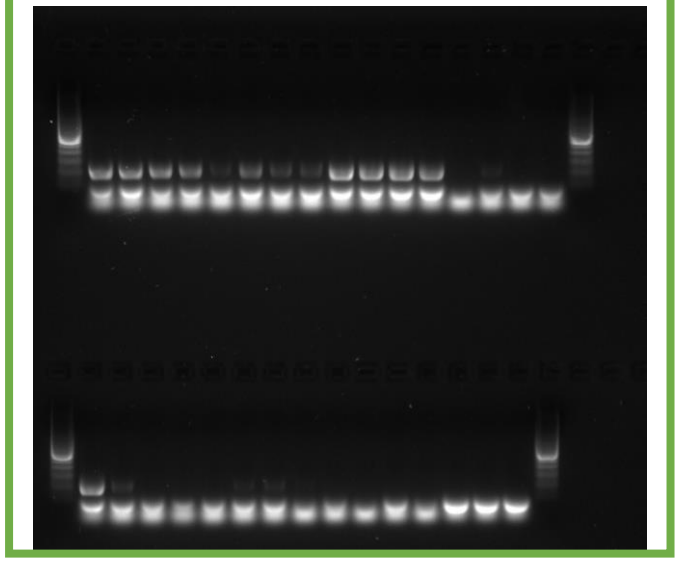
Petiole isolations
&
Single hyphal tip
pure cultures



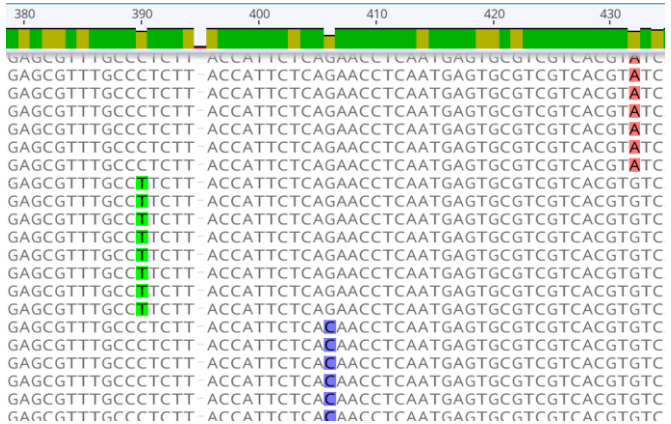
(-) for Burkhardt 2019 qPCR



(+) for Suga 2013 PCR

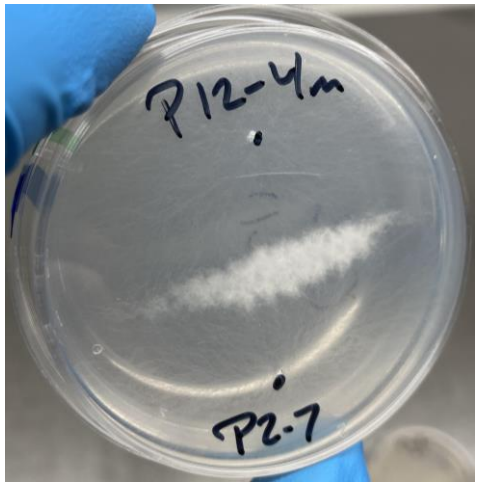


Sequence EF-1a gene



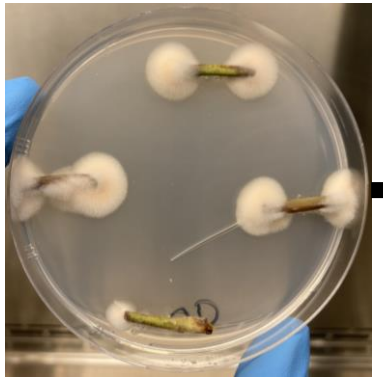
C->T
transversion

Somatic compatibility test



Current identification methods

Petiole isolations
&
Single hyphal tip
pure cultures



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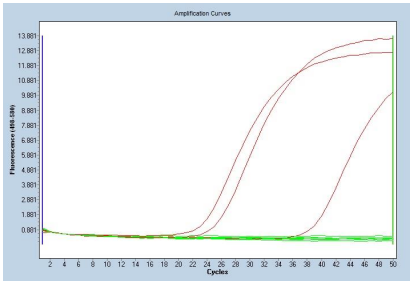

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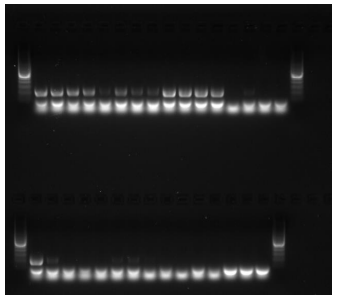
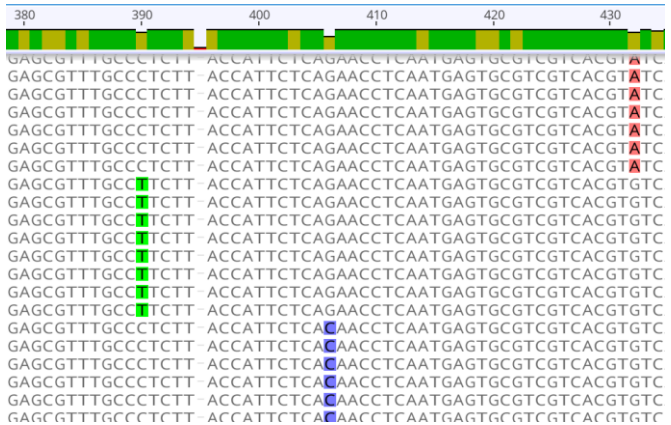


(+) for oxr2-TAR1 qPCR

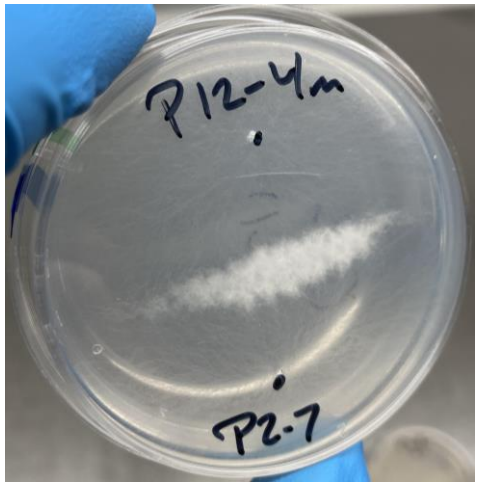
- Assay specific to CA Fof race 2
- Currently in beta-testing

Sequence EF-1a gene



C->T
transversion

Somatic compatibility test



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CALIFORNIA STRAWBERRY COMMISSION

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Agriculture and Natural Resources

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Only the Finest Berries™

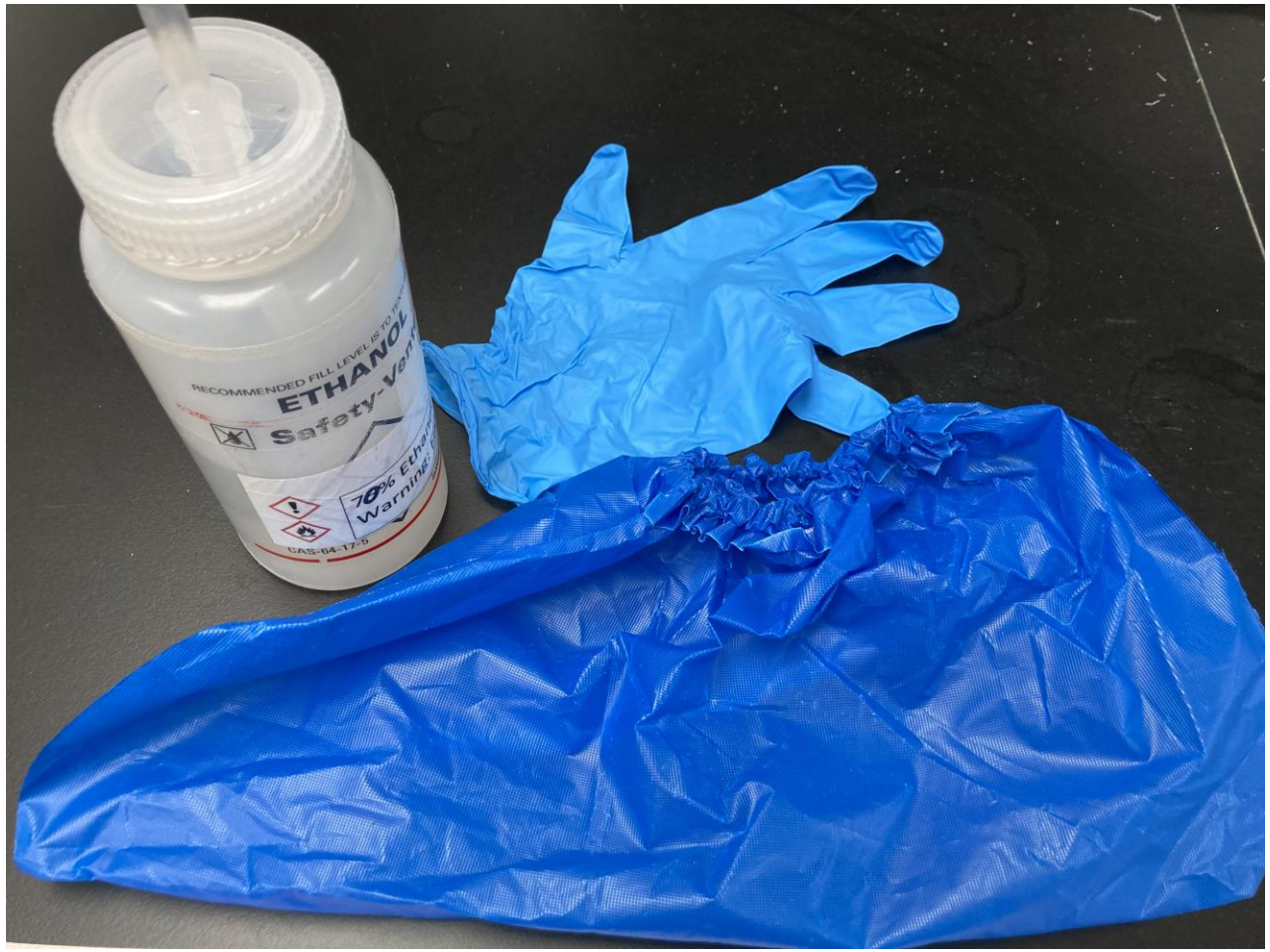
Jenny Broome
Kelly Ivors
Milton Bardmess
David Harada

CAL POLY
Strawberry Center

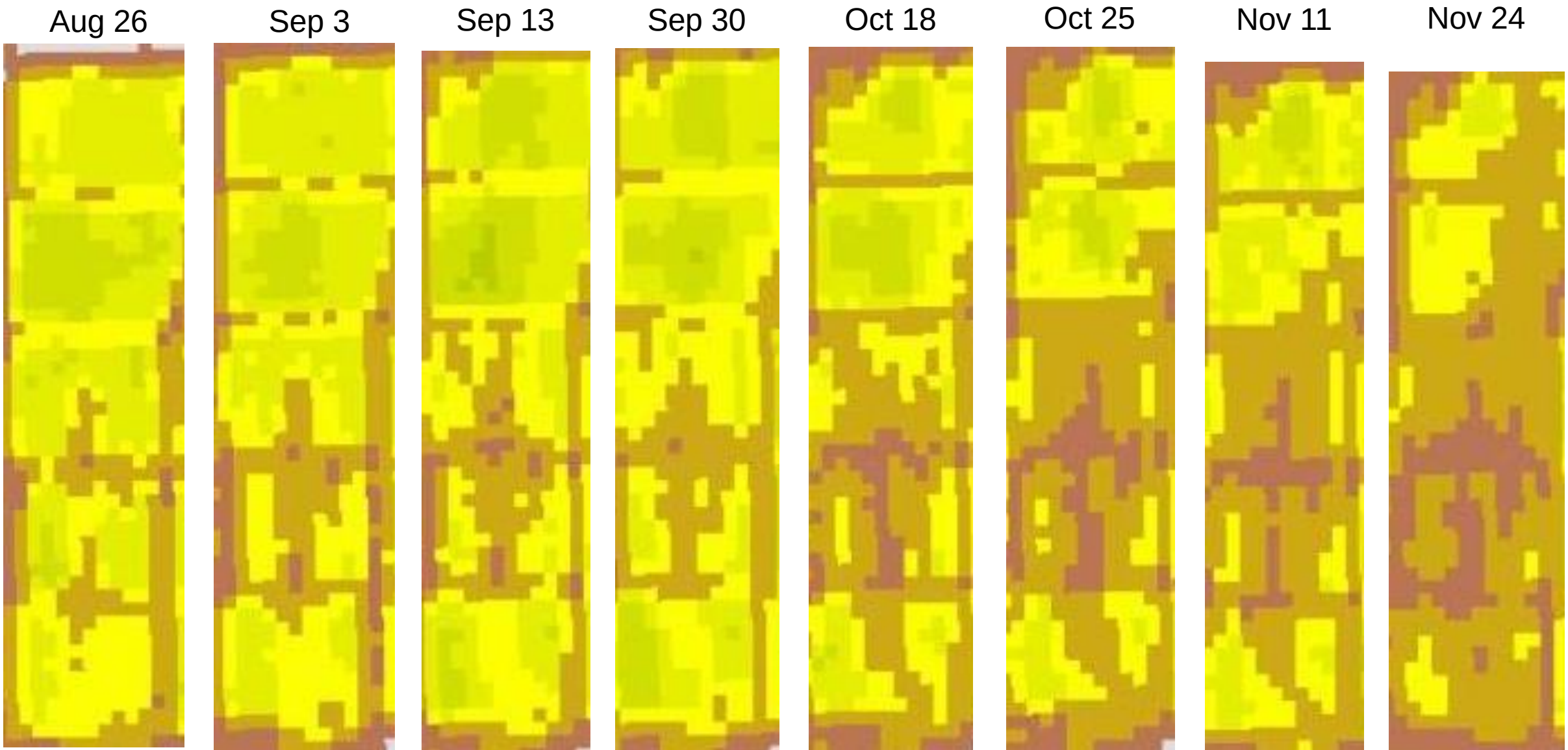
Gerald Holmes
Shashika Hewavitharana
Mary Steele

Biosecurity

- Nobody sampled other fields after visiting Ranch X
- New shoe covers and gloves were worn at every site
- Tools were cleaned and soaked in 70% ethanol for >10 minutes after samples collected



1 - Ranch X disease progression - NDVI



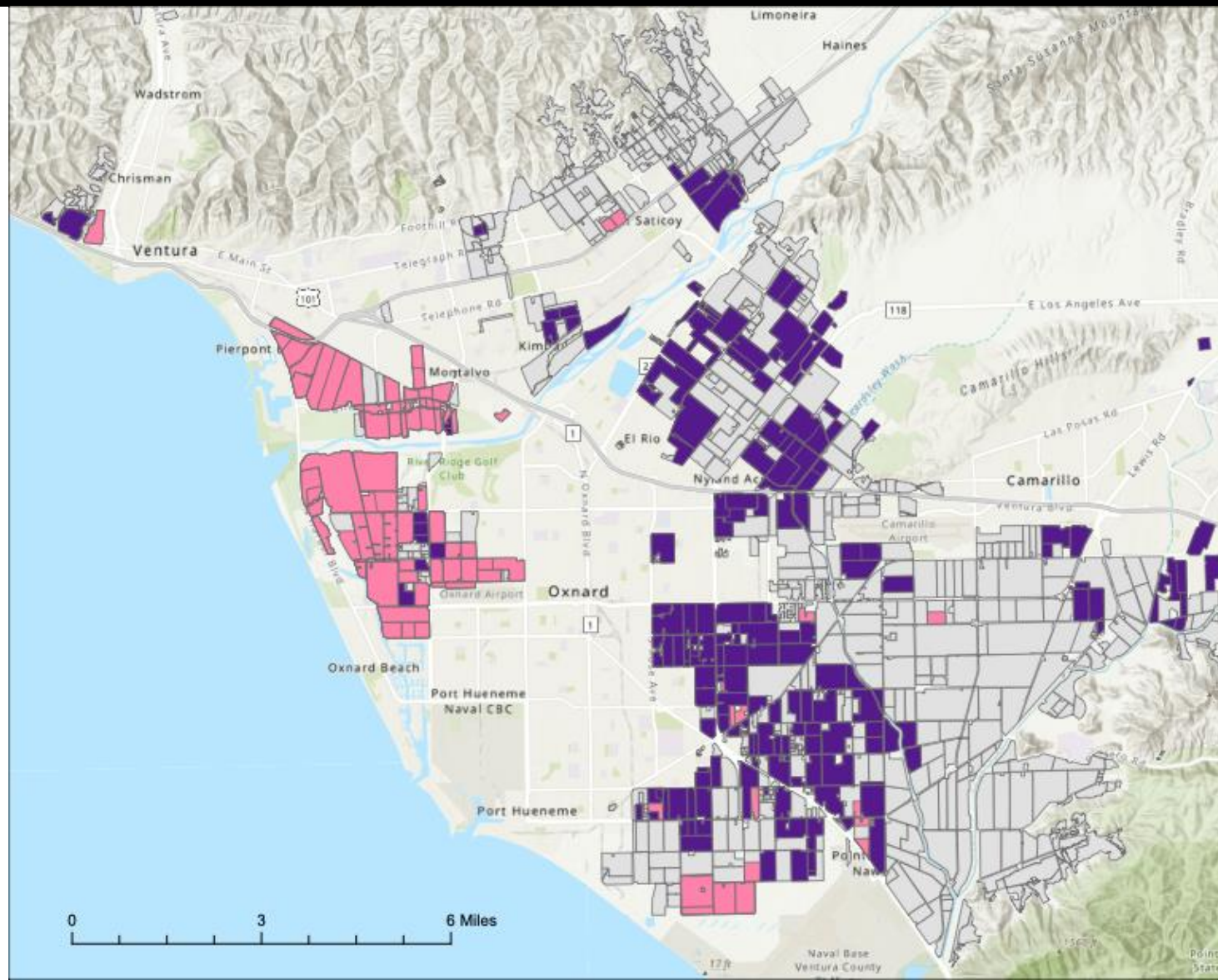
1 - *Fof* race 2 is widespread at Ranch X

● = Fof race 2 detected

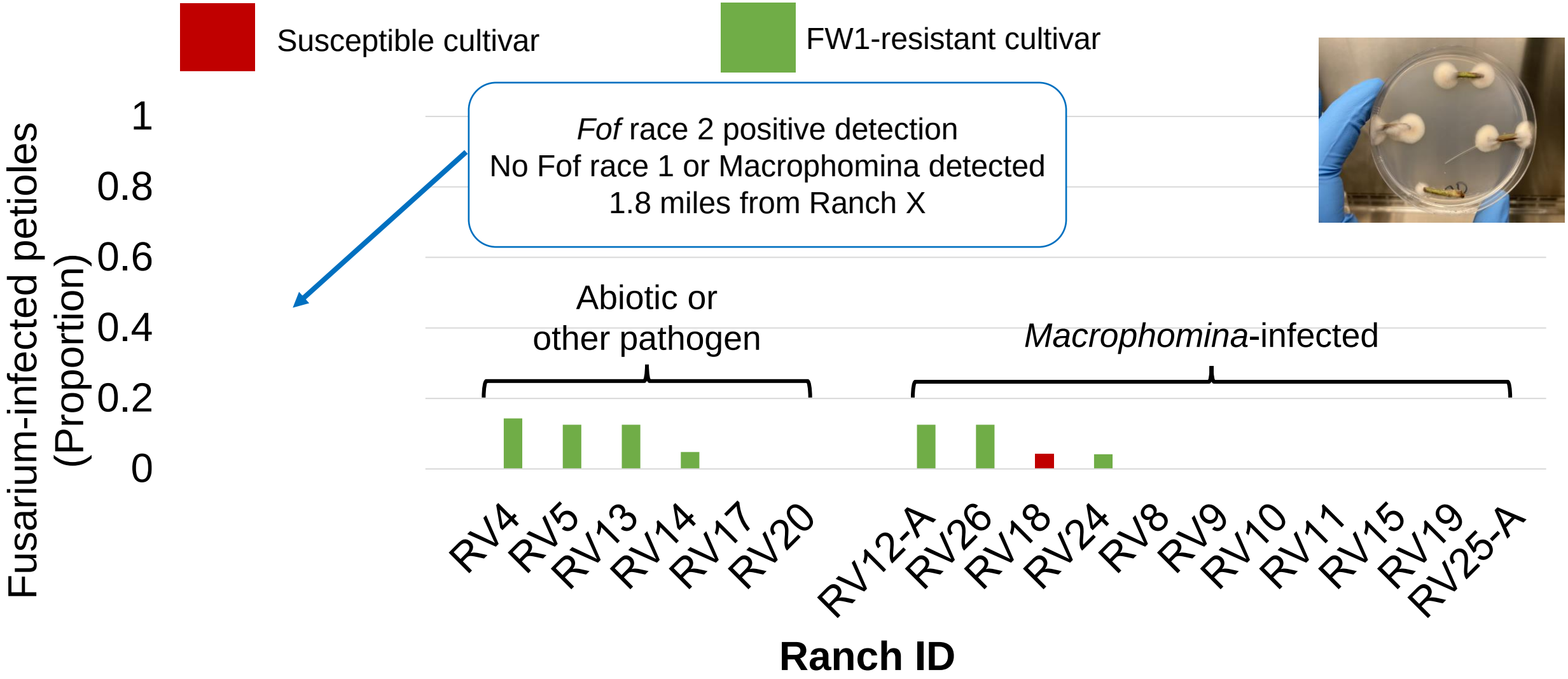
● = No Fof race 2 at this location

2 - Ventura county disease survey for *Fof* race 2

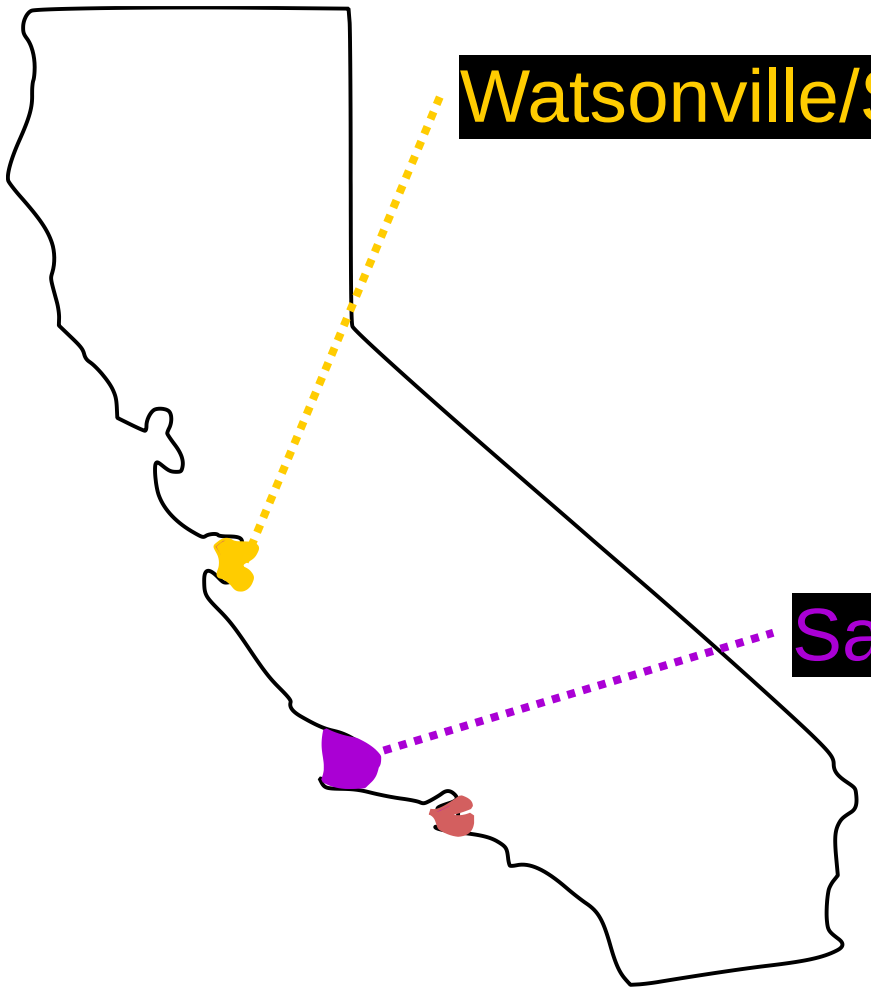
- ~30% of all summer planted fields
- Selected by:
  - Grower recommendation
  - NDVI variation
- Data collected:
  - Molecular assays for *Fof* race 1 and *Macrophomina*
  - Petiole assays selecting for *Fusarium oxysporum*



2 - Ventura county disease survey for *Fof* race 2



Fof race 2 unlikely to be present in other districts



- 146 fields sampled (2021-2022 – Cal Poly / USDA)
- Only 3 of these were suspicious (Fusarium-resistant cultivars with ambiguous result and moderate to high disease severity)

- 100 samples collected from 68 ranches (2022 – Cal Poly)
- Only 3 of these were suspicious (Fusarium-resistant cultivars with ambiguous result and moderate to high disease severity)

What we know

1. ***Fof* race 2 is identified in CA** for the first time
    1. Widespread at Ranch X
    2. Probably originated >1-2 years ago
2. **Common molecular methods do NOT detect** *Fof* race 2
    1. A DNA target specific to Oxnard race 2 has been identified
    2. qPCR and RPA assays are designed and in beta-testing.
3. ***Fof* race 2 is unlikely to be widespread**
    1. Likely to be present in 3-4 ranches in Ventura
    2. 2021-2022 Disease surveys in Watsonville, Salinas, and Santa Maria suggest it is not present yet in those regions
4. **The Oxnard race 2 strain is new to science**
    1. A single race 2 strain has been detected
    2. It has not been observed in extensive pathogen diversity surveys across 5 countries.

FW1-resistance remains effective in most fields

Acknowledgements

Grower collaborators

CALIFORNIA STRAWBERRY COMMISSION

USDA Agricultural Research Service

NIFA

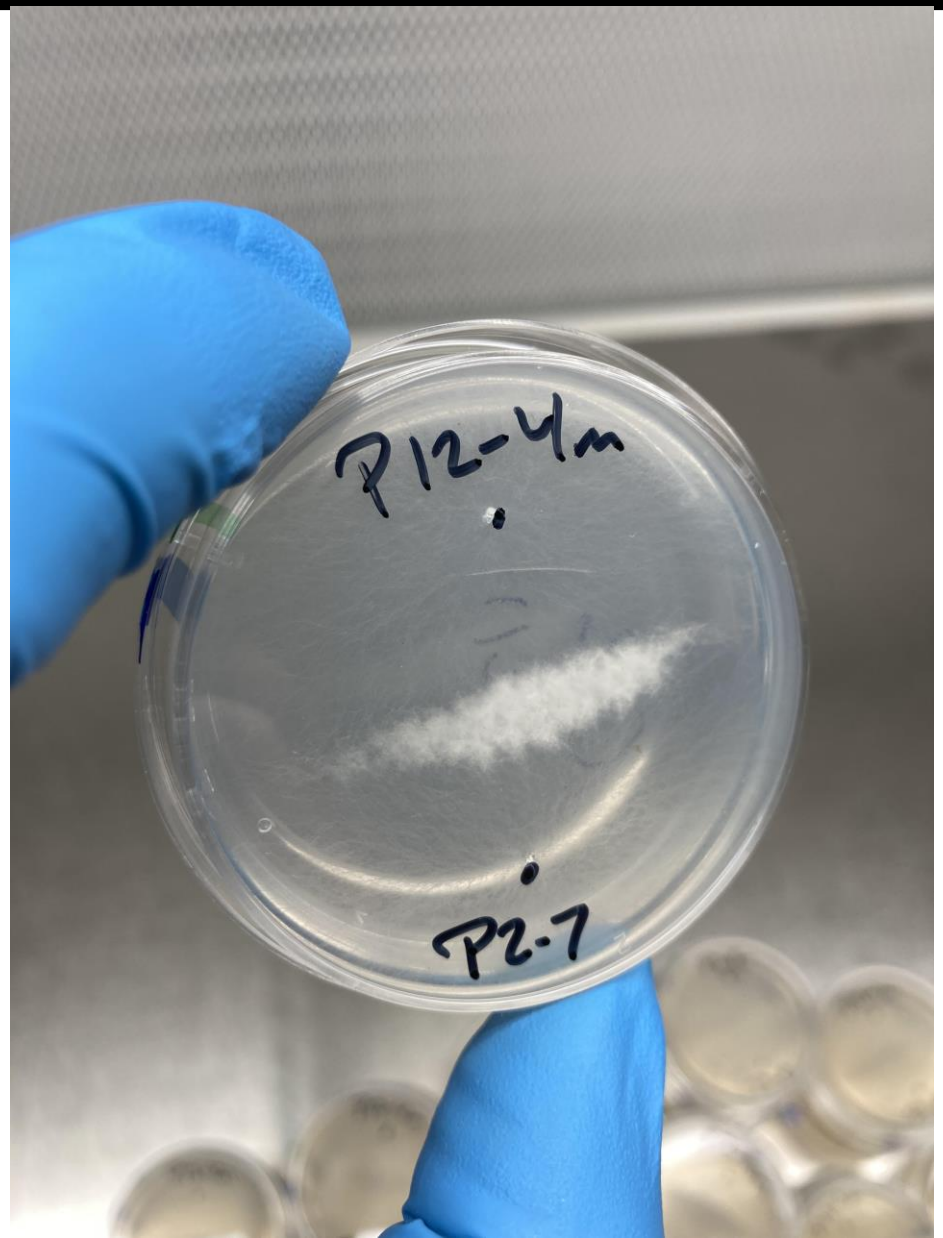
cdfa CALIFORNIA DEPARTMENT OF Food and Agriculture

NIFA Specialty Crops Research Initiative (#2017-51181-26833 and #2022-51181-38328)

A single strain identified at Ranch X

- “Somatic compatibility”
  - Phenotypic test for clonality
  - Takes 3-4 weeks to complete
  - Diagnostic method

- Single locus sequencing
  - Translation elongation factor 1-alpha
  - A unique single nucleotide polymorphism differentiates these strains



Oxnard race 2 is new to science

- Genome is distinct from all other known *F. oxysporum* strawberry pathogens
- Appears to have evolved by chromosome transfer between pathogenic and non-pathogenic lineage.
- Local origin is likely